

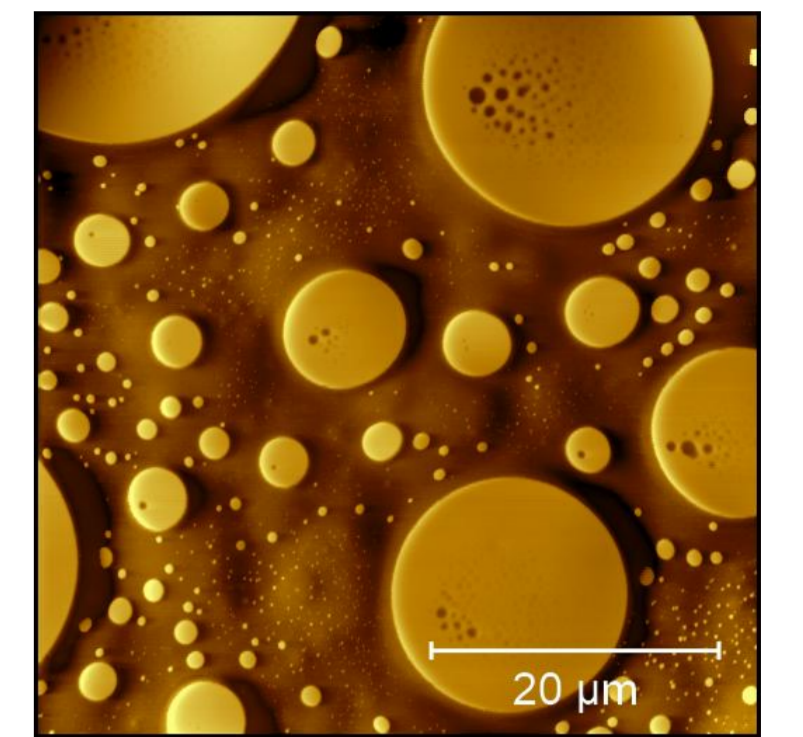
## Examination of filled polymers by AFM phase imaging

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### Introduction & Aim

- Atomic force microscopy (AFM) is not only suitable for imaging surfaces with nanometer-scale resolution, but also for investigating various mechanical and other physical properties of the sample surface [1]
  - While phase and amplitude modes highlight edges, the phase also depends on the sample hardness, surface elasticity, and the adhesion between the samples surface and the tip, thereby enabling a qualitative distinction between different materials on a surface (e.g. polystyrol/styrene-butadiene-styrene block-copolymer (PS/SBS) blend, from [2]) – but only for flat surfaces, e.g. embedded fibers cut along the diameter and polished [3]
- Here we show AFM measurements on polyamide (PA12) and resin blends with glass fibers, as an example for surfaces with extreme height differences, examined by AFM phase imaging and Raman microscopy



### Materials and methods

#### Polymer / glass fiber samples:

- Injection molded samples from PA12 with glass fibers – here shown: EOS PA 2200 and 3D Systems DuraForm PA Plastic with 3B Advantex chopped strands DS 1123D
  - Glass fiber bundles DS 3307 embedded in “High clear resin” (Anycubic) for UV photopolymerization
- Cutting and polishing with 4000 grade abrasive paper

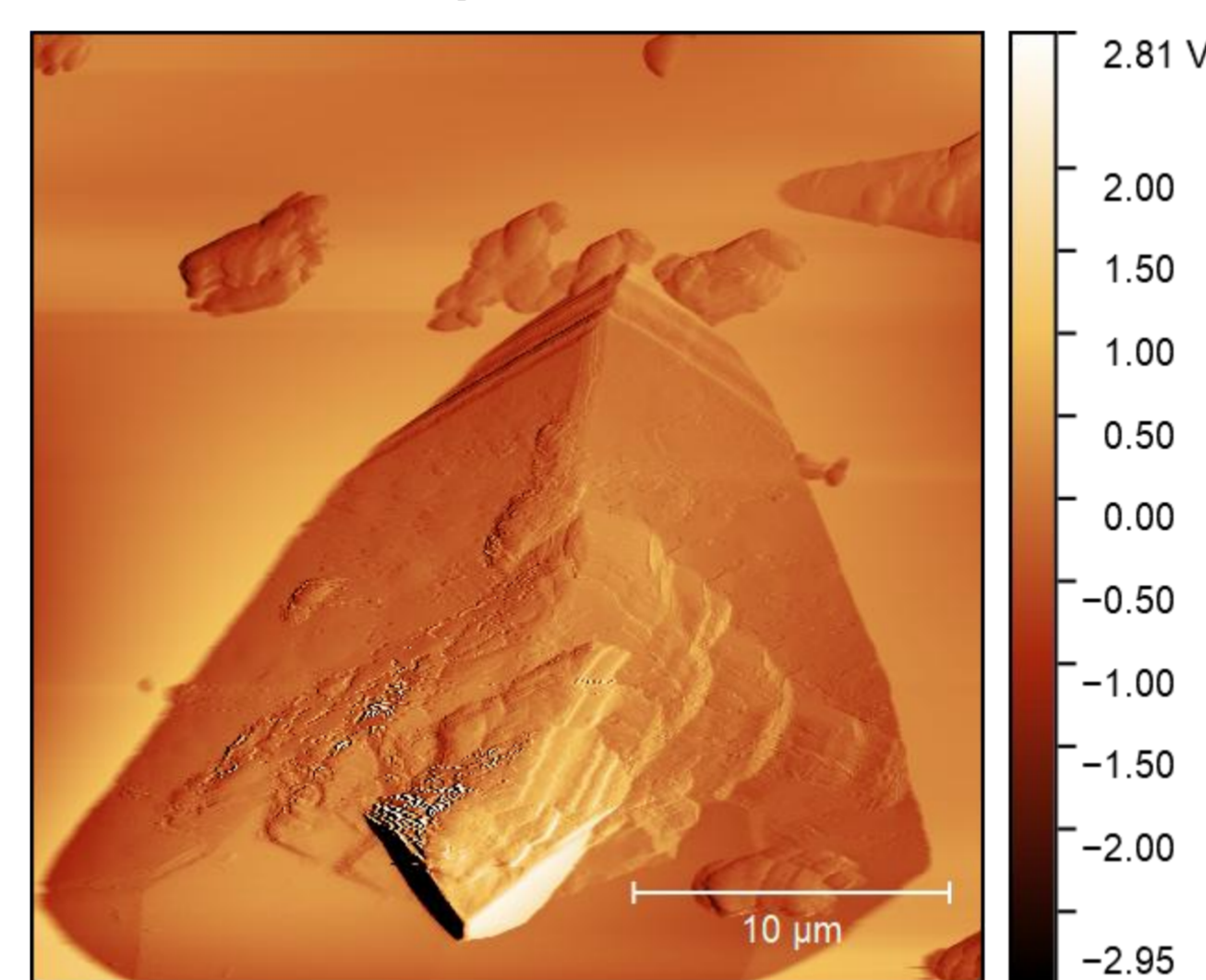
#### Characterization:

- Raman microscopy: WITec alpha300 apyron microscope
- AFM: FlexAFM Axiom (Nanosurf) in tapping mode with Tap190AI-G cantilevers

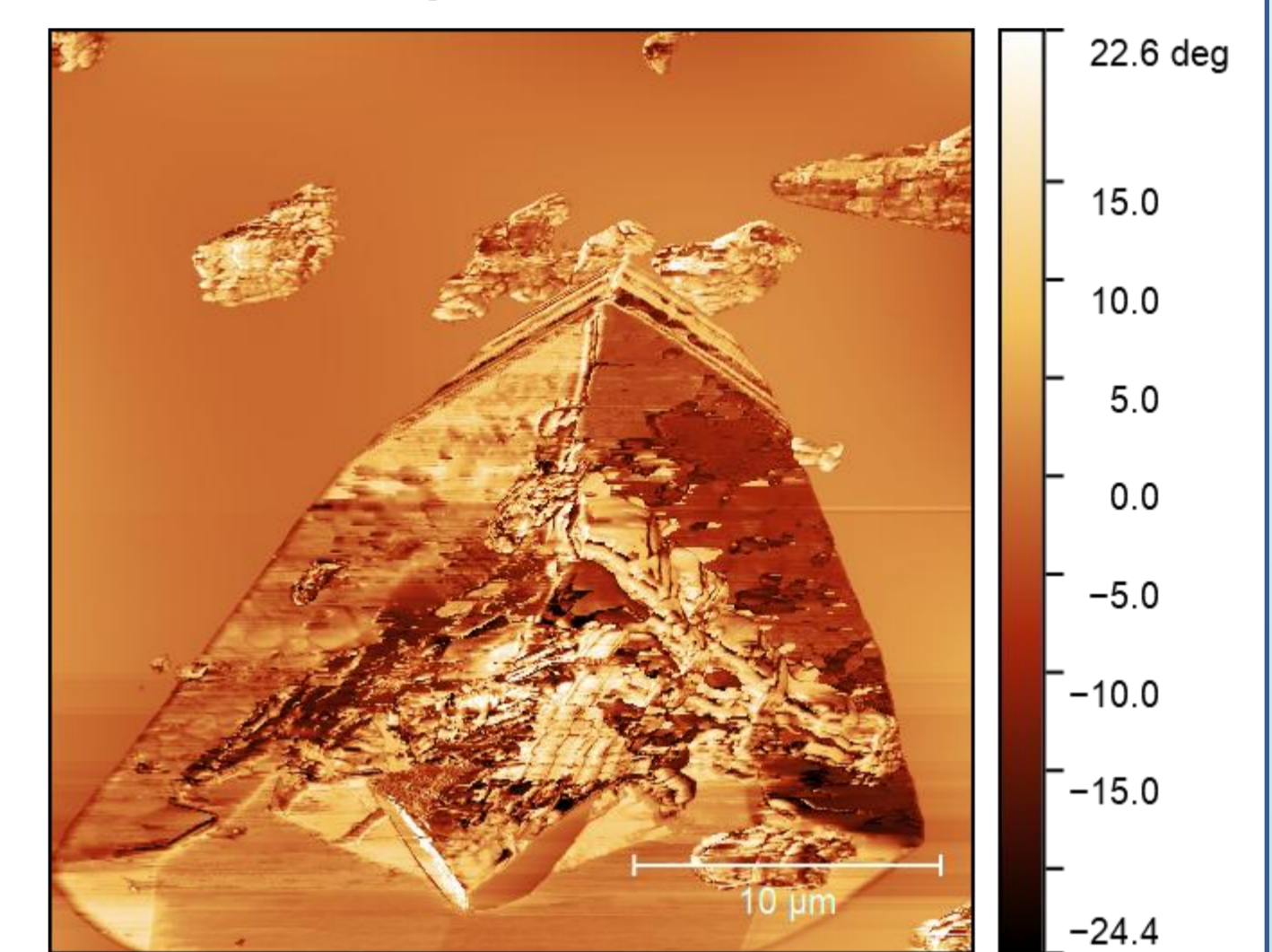
### Results – AFM

EOS PA 2200/DS 1123D:

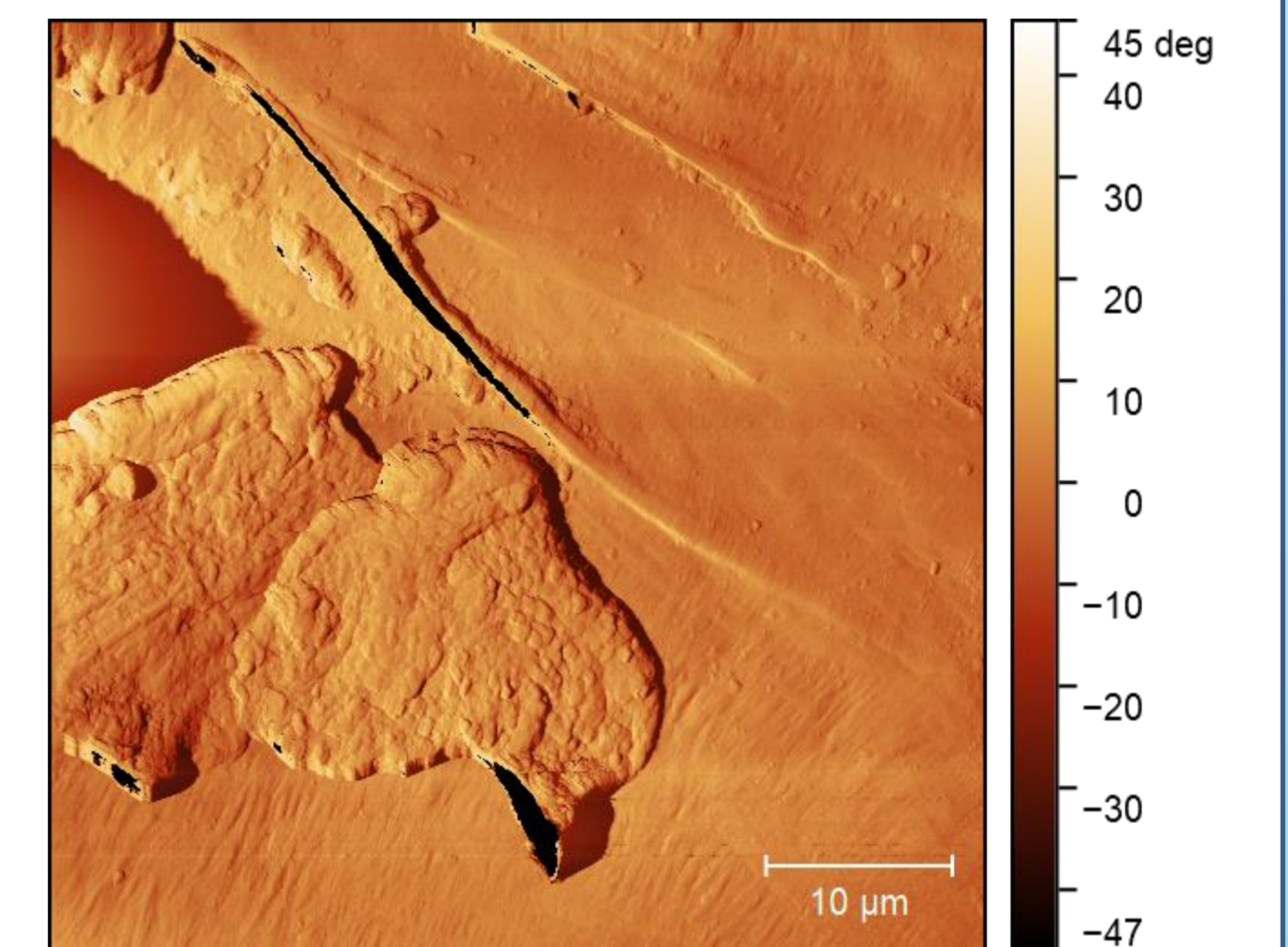
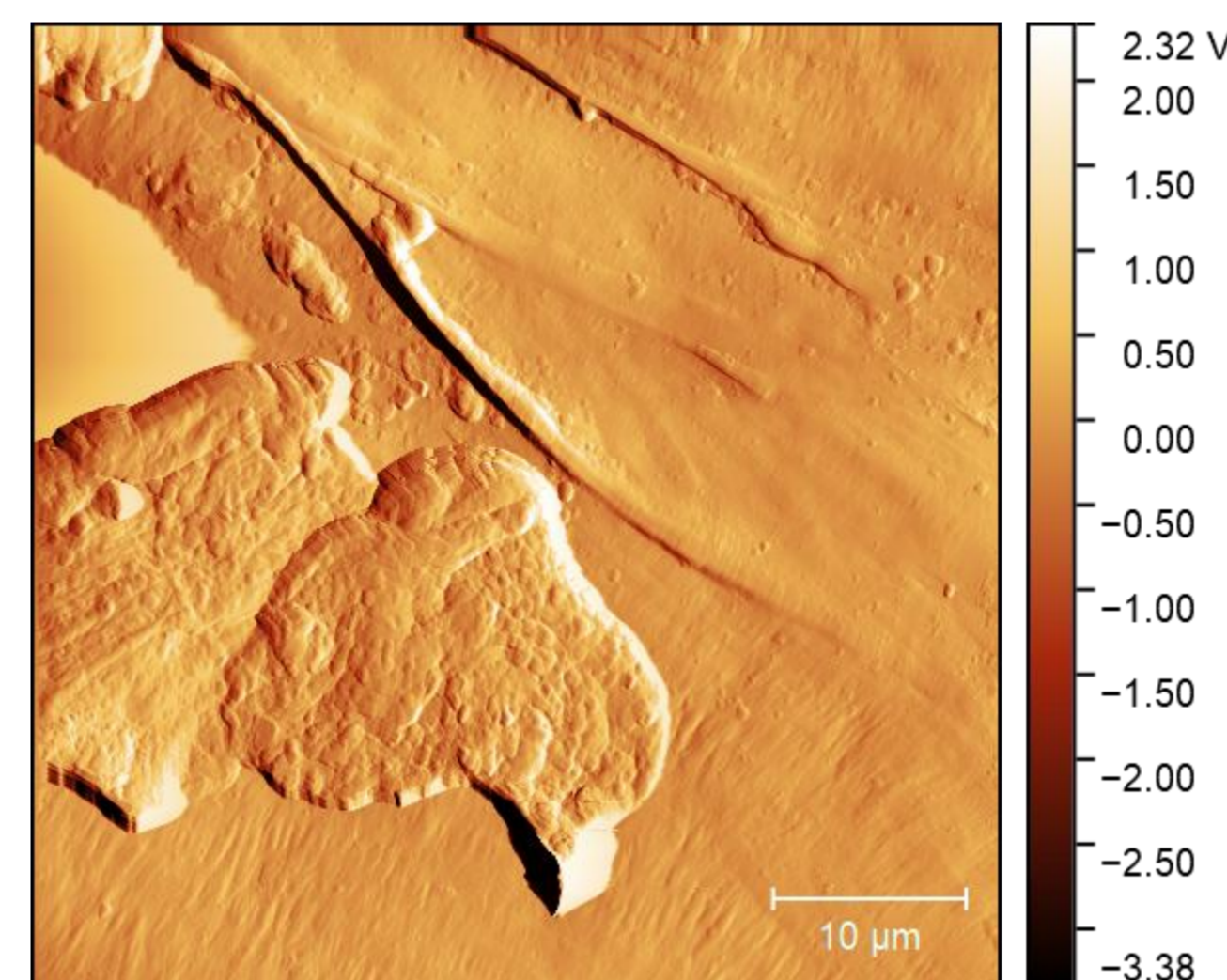
amplitude



phase

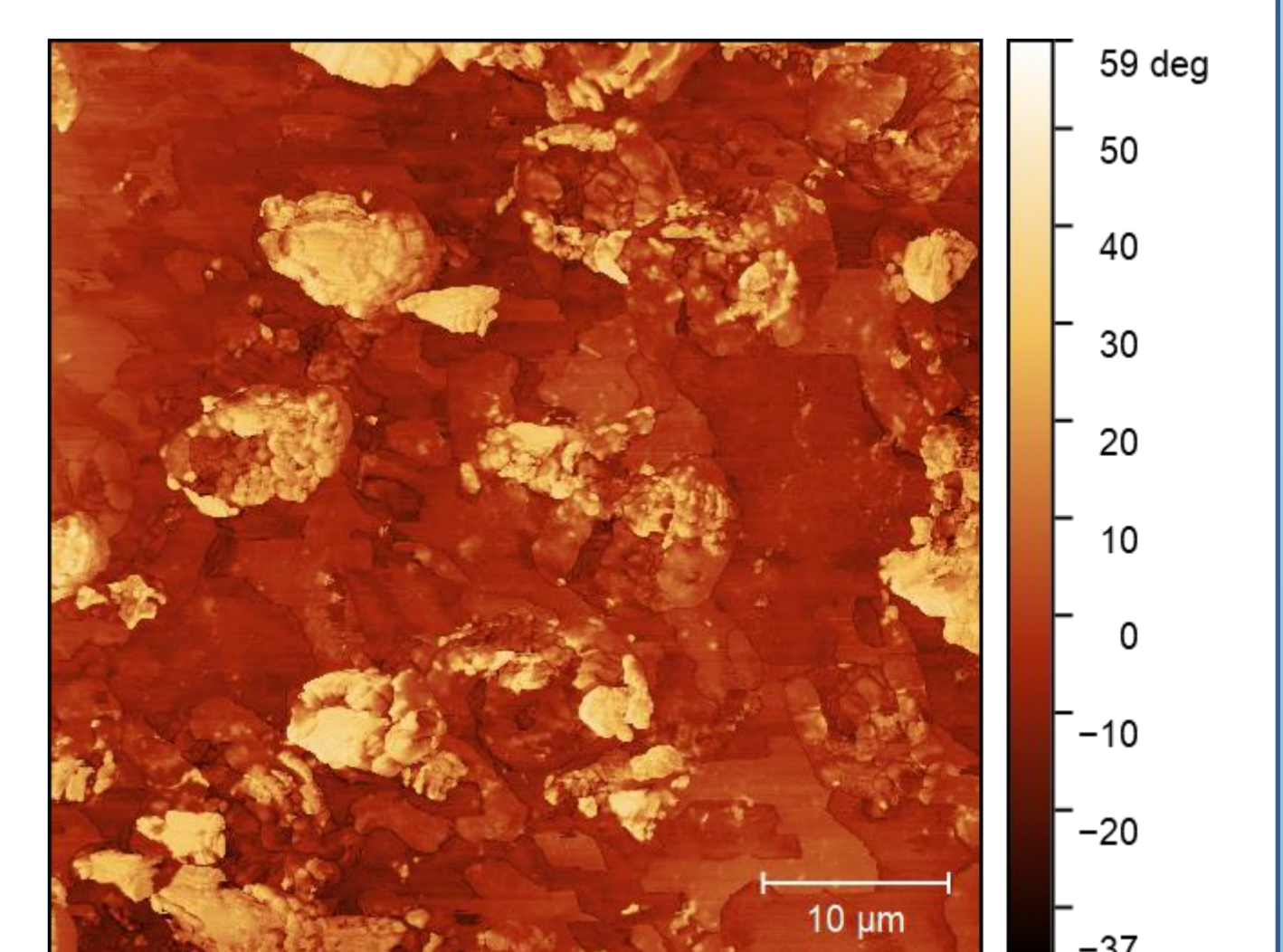
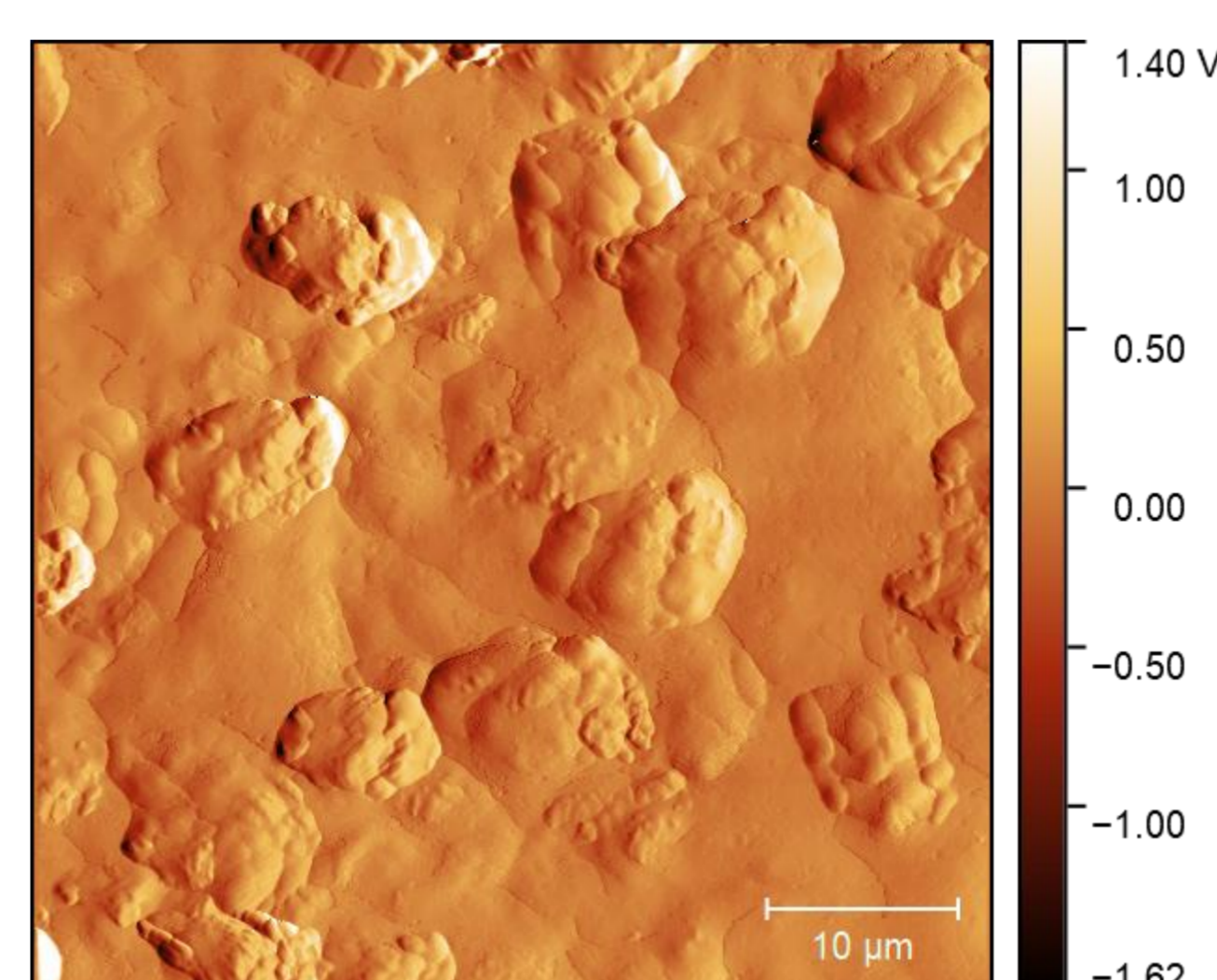


→ Fiber end visible in amplitude, but no clear phase contrast



→ Fiber fully embedded in polymer, not visible in phase image

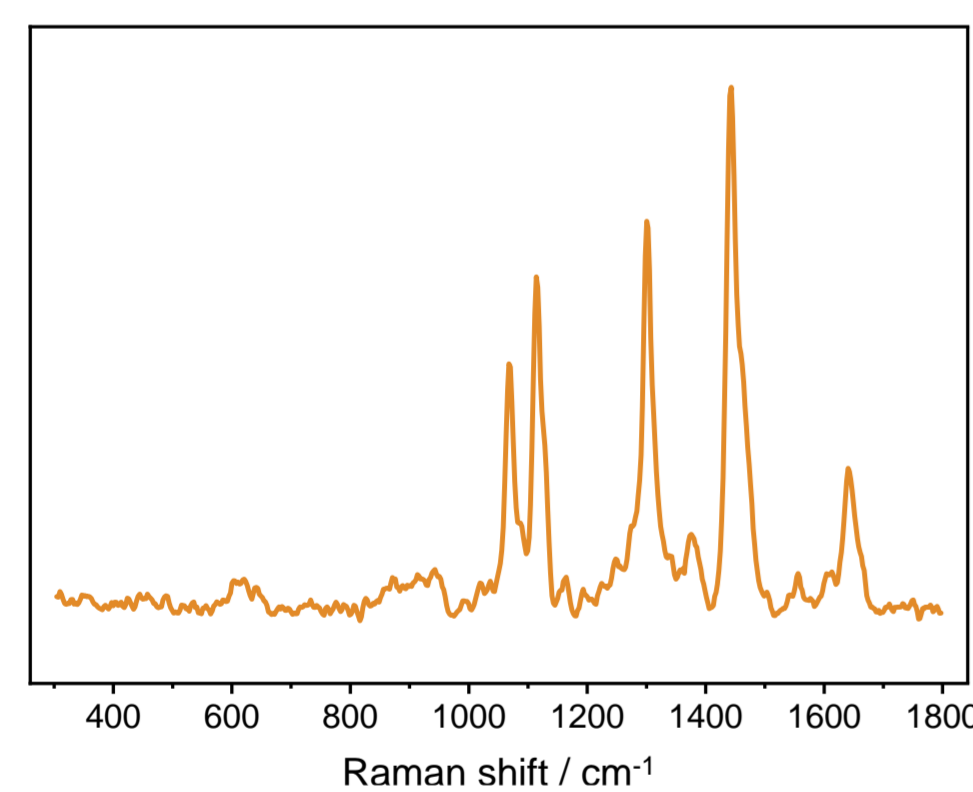
Fiber bundle in resin:



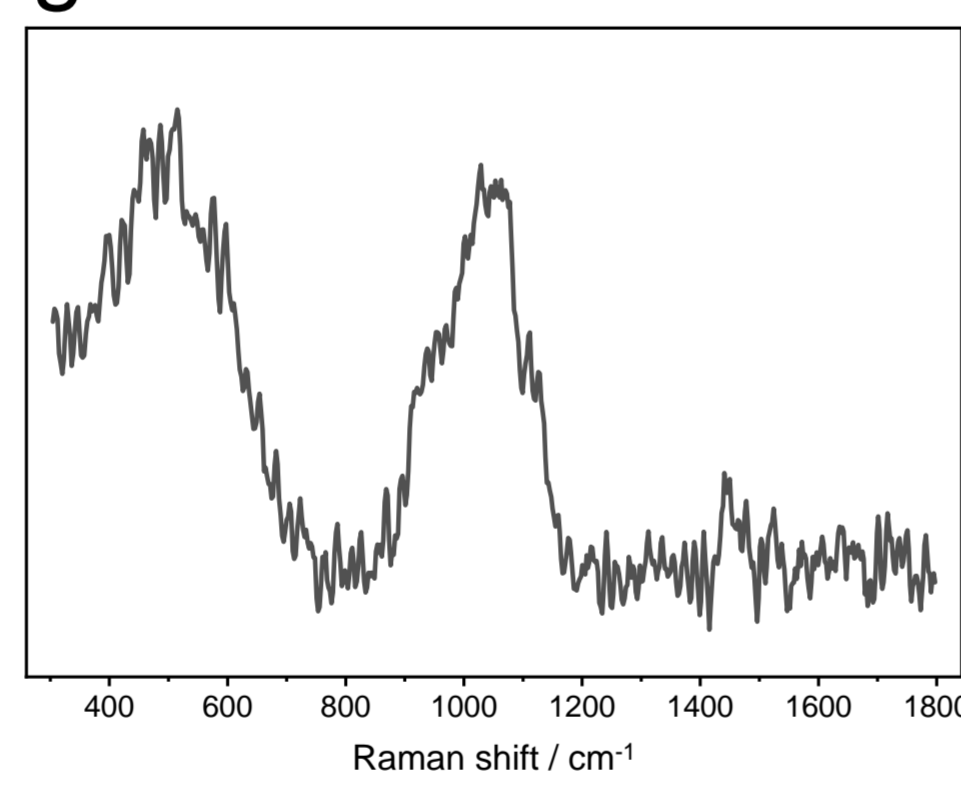
→ Fiber cross-sections visible in phase image

### Results – Raman microscopy

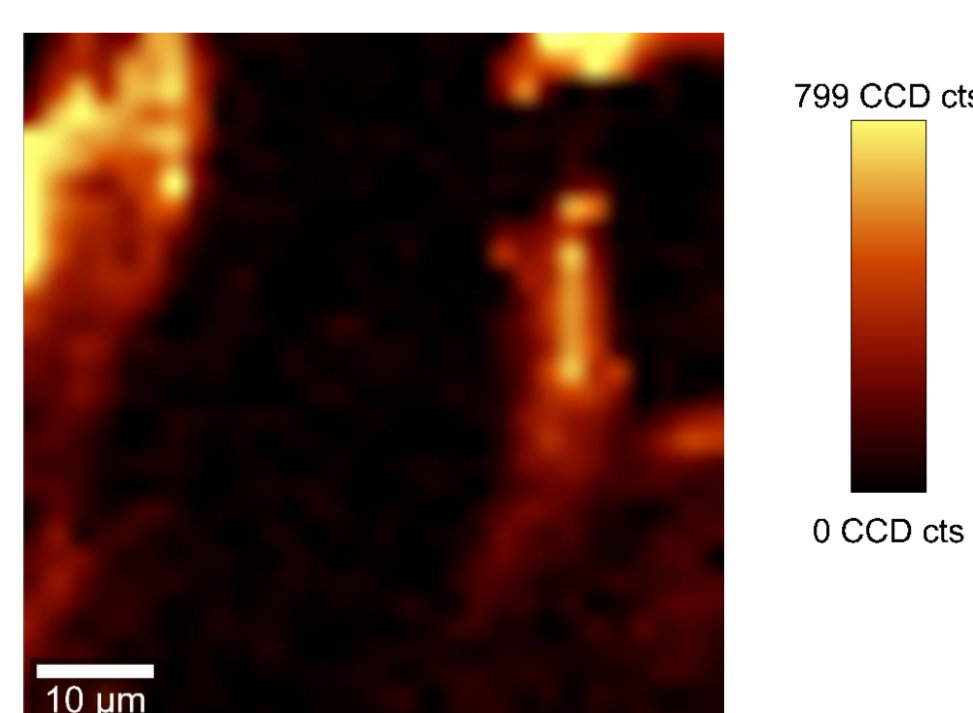
PA12



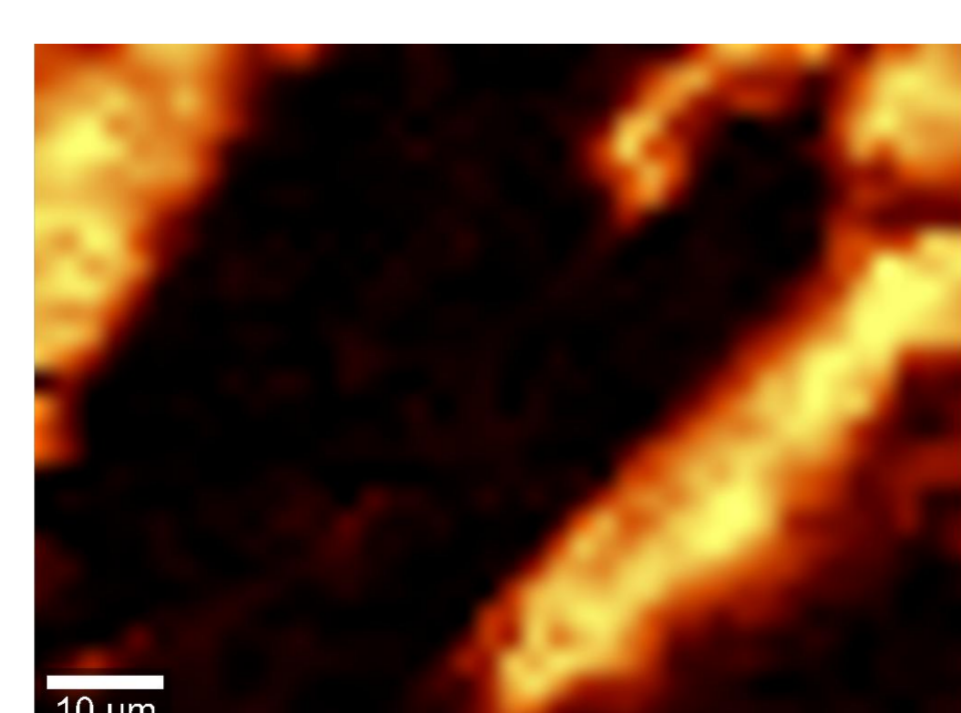
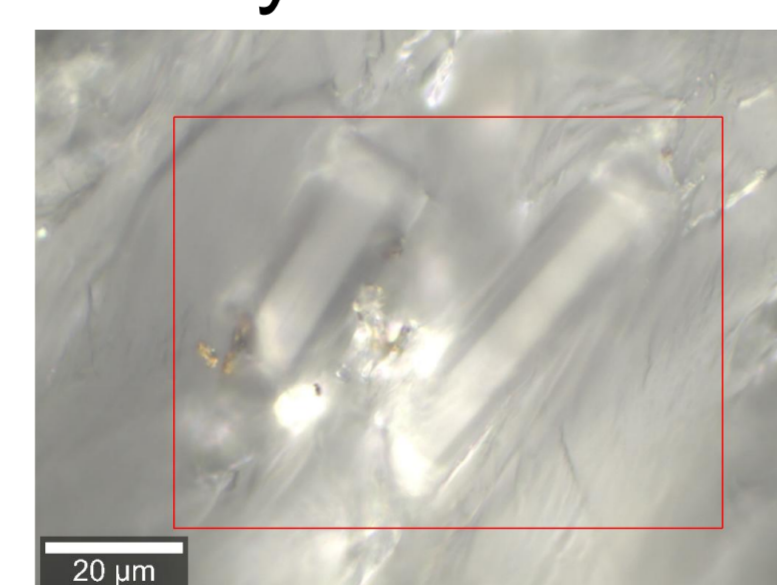
glass



EOS PA 2200/DS 1123D



3D Systems/DS 1123D



### References

- [1] Joshi, J.; Homburg, S. V.; Ehrmann, A. Atomic force microscopy (AFM) on biopolymers and hydrogels for biotechnological applications – possibilities and limits. *Polymers* **2022**, *14*, 1267.
- [2] Werner, E.; Güth, U.; Brockhagen, B.; Döpke, C.; Ehrmann, A. Examination of polymer blends by AFM phase images. *Technologies* **2023**, *11*, 56.
- [3] Wang, K.; Wu, J. S.; Zeng, H. M. Microstructures and fracture behavior of glass-fiber reinforced PBT/PC/E-GMA elastomer blends – 1: microstructures. *Comp. Sci. Technol.* **2001**, *61*, 1529-1538.

### Conclusion and Outlook

- Surface height differences around fibers up to 8 µm – usually below ~ 100 nm for AFM measurements  
→ side view on fibers nearly impossible to measure
- PA12 apparently fully covering fibers surface  
→ no phase image differences in AFM, but high contrast between glass fibers and polymer in Raman microscopy